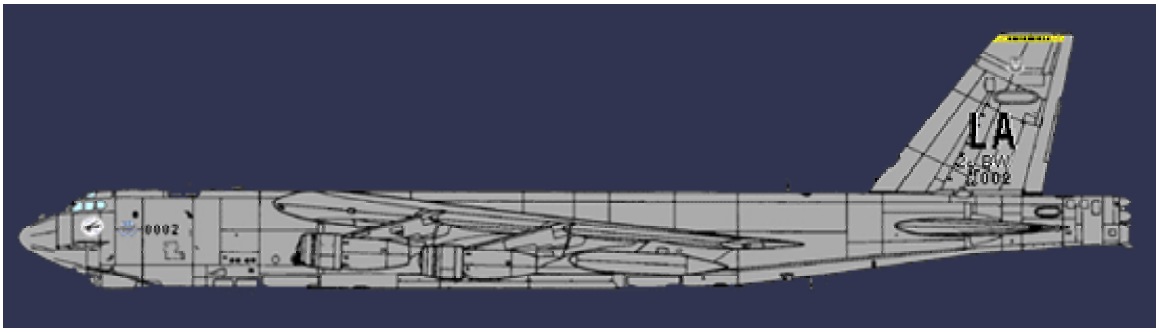



# Barksdale AFB, Bossier City, LA
# Headquarters of the US 8th Air Force

**Barksdale AFB Fuel Cell Demonstration Program**
**LOGANEnergy Corporation**
**Initial Project Description**
**December 31, 2003**


## Executive Summary

In October 2001, LOGANEnergy Corporation received a contract award from the US Army Corps of Engineers, Construction Engineering Research Lab to test and evaluate Proton Exchange Membrane (PEM) Fuel Cells at several DOD sites. Barksdale Air Force Base, Bossier city, LA, Headquarters of the 8th Air Force was one of the sites awarded to LOGAN. This PEM demonstration site is now operational after the initial start-up occurred on December 13, 2002.

Building #4650, an airman's dormitory building was chosen for the demonstration site. It hosts a 5kW, 120vac, SU-1 PEM technology demonstration unit manufactured by Plug Power Corporation, Latham, NY. The unit will operate in a grid parallel / grid synchronized configuration at 2.5kW for most of the one-year demonstration test program. The unit is instrumented with an external watt meter and a gas flow meter. A phone line will be connected to the power plant communications modem to callout to Plug Power with alarms or events requiring service and attention.

**Barksdale AFB FY'01 RESSDEM Program**

**Contents**

## Introduction

Fuel Cells convert the chemical energy of a fuel into useable electric and thermal energy without an intermediate combustion or mechanical process. In that respect, they are similar to batteries. However, unlike batteries, fuel cells oxidize externally supplied fuel and therefore do not need recharging. Ever since National Aeronautics and Space Administration (NASA) adopted fuel cell power for the Apollo Space program, American industry has been fascinated by the prospects for their use on earth as well.

When integrated with a fuel processor and a solid-state power conditioner, the power system becomes one that produces clean, quiet and reliable electric power and heat. Several manufacturers are currently hard at work to translate the basic technology into consumer products. As advances in PEM technology and mass production converge to introduce competitively costs systems into the marketplace, many are betting that small scale fuel cell generators will soon be ready to tackle thousands of residential and small scale commercial power applications. These new appliances will be packaged energy systems providing both heat and electricity that will be able to operate with or without the local utility grid.

Until recently, however, the promise of fuel cell technology has been slow to advance beyond a narrow beachhead commonly referred to as the "early adopter" marketplace. Broader market appeal has been constrained by fits, false starts and premature expectations raised by eager manufacturers; but also high prices, skepticism, and not a little resistance by parochial interests have all restricted the opportunity. Notwithstanding, during the decade of the 1990s, the UTC PC25C Fuel Cell program, largely assisted by a significant investment by DOD, gradually established a solid record of achievement and customer satisfaction at numerous US locations and around the world. Installations sites included military hospitals, commercial buildings, banks, food processing facilities, data processing centers, police stations, and airports.

While many of these "early adopters" hosted pure technology demonstration projects, the industry gained valuable experience and knowledge because of them. More recently, however, customers have warmed to the proposition that fuel cells have real performance advantages in various combined heat and critical power applications (CHP). Perhaps their attitudes and business practices may be adjusting to accommodate an uncertain energy landscape. Clearly, many energy providers are scrambling to maintain their market base, others are floundering, and still others are stalking new opportunity. Nevertheless, they are all discovering that informed consumers have gained new leverage through the power of choice. Increasingly, newspaper articles, periodicals and other media outlets are scoring direct hits with stories about fuel cells. Policy makers are out front raising expectations of a cleaner highly efficient fuel cell / hydrogen based economy of the future. The signals are clear. Initiative and momentum are driving a rapidly maturing fuel cell industry.

Certainly one reason is because fuel cell technology represents, perhaps, the most exciting and innovative development in the energy industry today. In some ways the technology is maturing more rapidly and markets are developing more quickly than the supporting infrastructure, codes and standards are able to accommodate. However, as technology demonstrations increasingly give way to CHP fuel cell installations that provide practical solutions to demanding consumer requirements, such roadblocks should get resolved as consumer and utility interests find common ground. For example, in most applications, large-scale fuel cell installations may off-load significant power resources during critical grid demand intervals, serving utility interests, while

providing "hot" back-up for mission essential loads in commercial and even residential applications. Additionally, they may also provide thermal Btus for heating and cooling loads- demonstrating the dual benefits of enhancing grid stability and promoting energy conservation.

At the small scale and residential end of the fuel cell spectrum, the opportunity is just as promising for the rapid expansion of distributed power generation. Conceivably, thousands of 3kW to 5kW CHP fuel cells in homes and small businesses across the country could within several years displace hundreds of MWhs of electricity and millions of thermal Btus with clean, efficient and reliable energy service. If this occurs, it could have a dramatic impact on both the energy industry, and on the nation's economy and security. Consumers, not utilities, could begin displacing environmentally disruptive generation methods, thereby forcing changes in the industry. As providers of grid resources, they may one day collectively enhance grid stability in many areas, boosting efficiency and conservation norms, and having a decided impact on the evolution of national energy policy.

Against this backdrop, the US Army Corps of Engineers, Construction Engineering Research Lab (CERL) has contracted with LOGANEnergy Corporation to engage a progressive fuel cell energy strategy to inform future DOD policy and planning. Broadly speaking, this engagement directs LOGAN to purchase and install residential and small-scale fuel cell power plants, and then test and evaluate their performance in widespread applications at selected military installations. Three seemingly incongruous events make this program very timely. They are (a) the complexities and perplexities of utility deregulation juxtaposed with, (b) base utility privatization programs, and (c) the nascent interest in distributed generation / CHP technologies that promise more efficient utilization of resources.

If the fuel cell industry appeared very much ahead of a languid power market in the recent past, today those markets are in comparative turmoil. Prices and availability, in some cases, are volatile and beyond the comprehension of energy managers and consumers alike. Consumers who are seeking innovative and efficient energy solutions for greater comfort, convenience and reliability are adding a new urgency. If the fuel cell industry can capitalize on these conditions, it will have a rich market opportunity, but it will have to deliver energy services and benefits that are immediate, site specific, cost effective, energy efficient, and certifiably green!

In order to test and evaluate the state of PEM fuel cell technology against these challenges, LOGANEnergy Corporation will demonstrate over the course of a year a PEM small scale fuel cell at Ft Bragg, NC. The project will be guided by an operations plan that will direct the installation, testing, evaluation and reporting on the performance of the unit. The objectives of the plan include;

1. Evaluating installation methods in order to help standardize safe and cost effective installation practices,

2. Evaluating "out of the box" reliability and interoperability with existing facility electrical and mechanical systems / infrastructure,

3. Evaluating actual PEM operating characteristics as compared to manufacturer representations,

4. Measuring the cost of operating a PEM unit under real market conditions,

5. Measuring, collecting and analyzing operating data including, total load hours, availability, kW production, fuel consumption, water consumption, forced outages, serviceability, and manufacturer's support.

6. Introducing PEM technology, power distribution and energy efficiency to DOD and local stakeholders in the community.

The project will be led by LOGANEnergy and supported by energy professionals within the fuel cell manufacturing and the fuel cell application/ service industry, including Plug Power and Energy Signature Associates.

## Ft. Bragg Site Selection

LOGAN and CERL personnel met at Barksdale AFB in mid July to discuss the demonstration project with the base facilities manager, Nathan Cost and other command representatives. After discussing the project objectives, the optimum fuel cell location and the need for easy access to natural gas, water and electricity, Mr. Cost led the party on a tour of the possible sites. The first site that the party investigated was a sanitary lift station adjacent to a residential subdivision depicted in Figure 1 below.

**Figure 1. Site 1, (sanitary lift station).**

Natural gas, power and water were all conveniently located within the fenced area at left. The site came up short because it did not offer a freeze protected interior space to install the R/O filtration unit.

After leaving the lift station the party toured the new gymnasium facility seen in Figure 2 below. The site offered several attractive possibilities particularly as it could provide a very visible showcase of the fuel cell itself. However the site could not provide a convenient electrical service interface for the fuel cell so it was rejected.

The third site see in Figure 3 below proved to offer the best possible choice. It is adjacent to Building 4650, which is an airman's' dormitory. The doorway in the photo leads directly into the building mechanical room that provided the necessary water and power interfaces. Natural gas was also available just behind the chiller in the photo below.

**Figure 2. Site 2 (gymnasium facility).**

**Figure 3. Site 3, adjacent to Building 4650 (an airman's' dormitory).**

Figures 4 and 5, below are photos of the fuel cell after being rigged onto its pad on November 5, 2002 adjacent to Building 4650, but prior to the installation and start-up.

The hedge row seen in the photos had to be trimmed in order rig the fuel cell into place. After a brief interruption in the process the base agreed to allow the rigging to proceed.

Figures 6-10 below are photos of the installed unit and ancillary equipment at Building 4650.

Figure 6 above indicates the fuel cell electrical connection to the generator disconnect switch. Figure 7, above, is a photo taken at an angle that identifies the natural gas regulator and fuel cell meter in the background. Figure 8, above, is a photo of the wall mounted R/O unit that supplies filtered water to the fuel cell. Figure 9, above, is a photo of the 120/240 electric transformer that was installed to convert the fuel cell inverter output of 120vac up to 240vac so the power could be properly distributed through the facility. Figure 10, above right, is a photo of the load panel

located in the mechanical room of Building 4650 indicating the two 30 amp breakers tying the fuel cell into the facility's electrical distribution.

**Figure 4. Fuel cell adjacent to Building 4650.**

**Figure 5. Fuel cell on pad, prior to the installation and start-up.**

**Figure 6. Fuel cell electrical connection to the generator disconnect switch.**

**Figure 7. Natural gas regulator and fuel cell meter.**

**Figure 8. Wall mounted R/O unit that supplies filtered water to the fuel cell.**

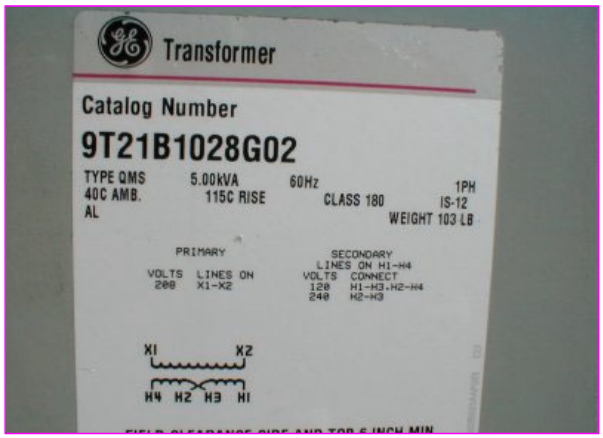
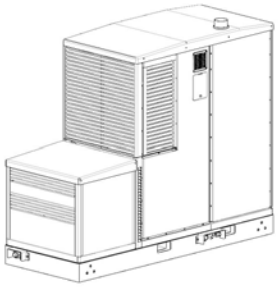



**Figure 9. Electric transformer.**


**Figure 10. Load panel.**

## SU-1 Product Specifications

**Stationary Unit 1 (SU1) is a 5kWAC on-site power generation system fueled by natural gas. Designed to be connected to the existing power grid, SU1 is a clean and efficient source of power.**



**Specifications**

| | | |
|---|---|---|
| Physical | Size (L X W X H): | 84½ X 32-in. X 68□-in. |
| Performance | Power rating: | 5kW continuous |
| | Power set points: | 2.5kW, 4kW, 5kW |
| | Voltage: | 120/240 VAC @ 60Hz |
| | Power Quality: | IEEE 519 |
| | Emissions: | NOX < 5ppm |
| | | $SO_X$ < 1ppm |
| | | Noise < 70 dBa @ 1m |
| Operating Conditions | Temperature: | 0 to 104°F |
| | Elevation: | 0 to 750 ft |
| | Installation: | Outdoor |
| | Electrical Connection: | Grid Parallel |
| | Fuel: | Natural Gas |
| Certifications | Power Generation: | CSA International |
| | Power Conditioning: | UL |
| | Electromagnetic Compliance: | FCC Class B |
| Dimensions | | |
| Length | | 84 in. |
| Width | | 32 in. |
| Height | | 68¼ in. |
| Operating Requirements | | |
| | Fuel Type | Natural Gas |
| | Temperature | 0 to 104 °F |
| Outputs | | |
| | Power Output | 5kW |
| | Voltage | 120/240 VAC @ 60Hz |
| | Noise | < 70 dBA@ 1 m |
| Certifications | | |
| | CSA International | Fuel Cell System |
| | UL | Power Conditioning Module |

**Figure 11. Plug Power Fuel Cell System.**

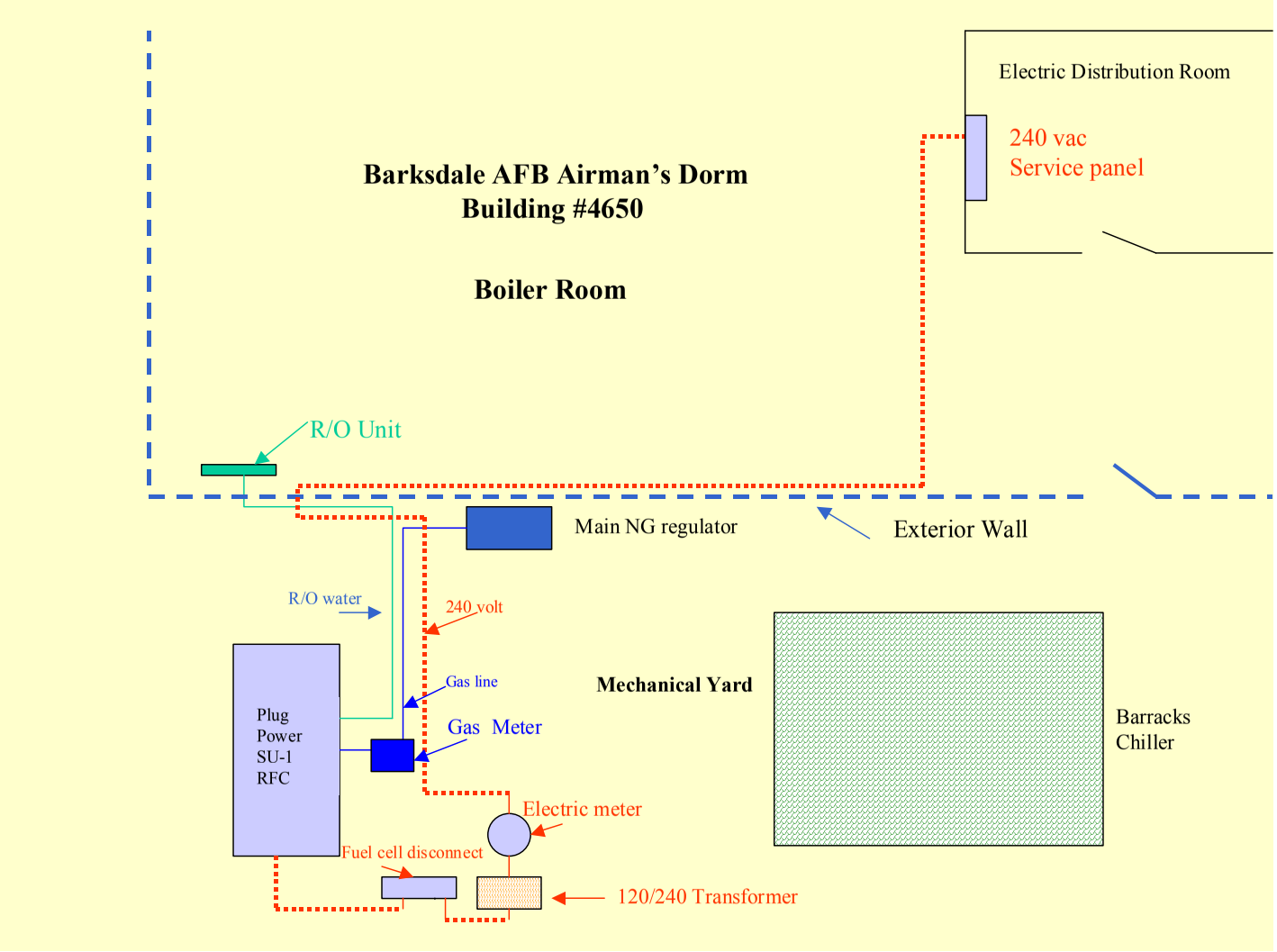



**Figure 12. Barksdale AFB PEM installation plan showing "as built" installation plan for the FY'02 RESSDEM PEM project.**

## Installation Application

The installation tasks were completed on November 11, 2002. The initial start of the Barksdale unit was attempted on November 22, 2002, but was not successful because the unit's batteries were depleted before a successful start could occur. In addition attempts to start the unit followed over the next two weeks with several issues hampering progress including, a week of inclement weather, troubleshooting a failed thermal couple (TC), repairing a failed weld in the reformer Proxair section, a failed battery charger, troubleshooting a stuck valve on the humidifier, and generally learning to operate the unit. The first start and installation certification took place on Dec 13, 2003; at which time the unit ran continuously for 8 hours.

Figure 10, above, lists the specifications of the Plug Power SU-1 PEM technology demonstration fuel cell installed at Barksdale Air Force Base.

Figure 11, above, diagrams the location of the fuel cell pad in relationship to the utility interfaces including, power and water in the adjacent mechanical room, and the natural gas supply seen in Figures 6 & 7. The natural gas piping run is approximately 12 feet, the R/O water piping run is approximately 25 feet, and the electrical conduit run is approximately 40 feet.

The SU-1 inverter in the Barksdale fuel cell has a power output of 120 VAC at 60 Hz. However, the distribution panel in the mechanical room has connected loads at 240 VAC. In order to accommodate the loads in the facility voltage, a 120/249 step-up transformer was installed between the fuel cell and the load panel indicated in Figures 9 & 11.

Gas supply comes from a gas meter on the exterior wall of Building #4650 indicated in Figures 6 & 11. A regulator was installed at the fuel cell gas inlet to maintain the correct operating pressure.

A Plug Power supplied Reverse Osmosis water filtration system was installed in the boiler room of Building #4650 to provide filtered process water to the power plant. Water will be piped to the fuel cell as indicated in Figures 8 & 11 above, and a heat strip will wrap the piping to prevent freezing.

A phone line will be provided to the fuel cell modem to establish communications with Plug Power and LOGAN customer support functions.

In preparation for the installation, LOGAN processed a digging permit issued by the Civil Engineering department at Barksdale AFB. No other permits were required at this site.

Prior to starting the unit the items covered in Figure 12, below, were completed. Then, once the unit was started, the unit was tested and monitored in accordance with the factory recommended procedures listed in Figure 13, below.

Service incidents and facility calls will be reported on the sample Service Call Report form listed below as Figure 14.

An Economic Analysis of the Ft Bragg RESSDEM project appears in Figure 15.

**Installation Check List**

| *TASK* | **SIGN** | **DATE** | **TIME(hrs)** |
|---|---|---|---|
| ***Batteries Installed*** | Keith Williams | **11/20/02** | **1** |
| ***Stack Installed*** | Keith Williams | **11/20/02** | **1** |
| Stack Coolant Installed | Keith Williams | **11/20/02** | **1** |
| ***Air Purged from Stack Coolant*** | Keith Williams | **11/20/02** | **.5** |
| Radiator Coolant Installed | Keith Williams | **11/20/02** | **1** |
| Air Purged from Radiator Coolant | Keith Williams | **11/20/02** | **.5** |
| J3 Cable Installed | Keith Williams | **11/20/02** | **.5** |
| J3 Cable Wiring Tested | Keith Williams | **11/20/02** | **.5** |
| Inverter Power Cable Installed | Keith Williams | **11/20/02** | **10** |
| Inverter Power Polarity Correct | Keith Williams | **11/20/02** | **.5** |
| RS 232 /Modem Cable Installed | Keith Williams | **11/20/02** | |
| DI Solenoid Cable Installed with Diode | Keith Williams | **11/20/02** | **4** |
| Natural Gas Pipe Installed | Keith Williams | **11/20/02** | **9** |
| DI Water / Heat Trace Installed | Keith Williams | **11/20/02** | **7** |
| Drain Tubing Installed | Keith Williams | **11/20/02** | **2** |

**Figure 13. Factory-recommended procedures.**

**Commissioning Check List**

| *TASK* | **SIGN** | **DATE** | **TIME (hrs)** |
|---|---|---|---|
| ***Controls Powered Up and Communication OK*** | Keith Williams | **11/20/02** | **1** |
| ***SARC Name Correct*** | Keith Williams | **11/20/02** | **.5** |
| Start-Up Initiated | Keith Williams | **11/20/02** | **.5** |
| Coolant Leak Checked | Keith Williams | **11/20/02** | **.5** |
| Flammable Gas Leak Checked | Keith Williams | **11/20/02** | **2** |
| Data Logging to Central Computer | Keith Williams | **11/20/02** | **.5** |
| System Run for 8 Hours with No Failures | Keith Williams | **12/13/02** | **11** |

**Figure 14. Service call Report form.**


SERVICE CALL REPORT SYSTEM INFORMATION

System Serial #: _____ Date _____

Purpose of Service Call: ☐Repair ☐Maintenance ☐ECN (Check all that apply)

Date Time

Date/Time shutdown _____ _____

MAINTENANCE / REPAIR INFORMATION

Service Tech Name: _____

Travel Man-hours: _____

Troubleshooting Manhrs: _____

Repair Man-hours: _____

Spare Part Delay Time: _____

Work Performed:_____
_____
_____Technician
Comments:_____
_____
_____
_____

FAILURE REPORT SUMMARY

| Date Initials | Description of Problem | Rpt # | | |
|---|---|---|---|---|
| | | | | |

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

Figure 15

**LOGANEnergy Corp.**

FY' 01 RESSDEM PROGRAM
Barksdale PEM Fuel Cell Economic Analysis

| | | | | | |
|---|---|---|---|---|---|
| Utility Rates | | | | | |
| 1) Water (per 1,000 gallons) | | $1.69 | | | |
| 2) Electricity (per KWH) | | $0.0655 | | | |
| 3) Natural gas ( per MCF) | | $5.80 | | | |
| | | | | | |
| Estimated First Cost | | | | | |
| Plug Power 5 kW SU-1 | | | $42,500 | | |
| Shipping | | | $1,000 | | |
| Installation electrical | | | $2,200 | | |
| Installation mechanical | | | $2,400 | | |
| Watt Meter | | | $800 | | |
| Site Prep, labor materials | | | $925 | | |
| Technical Supervision | | | $6,500 | | |
| Training | | | $5,000 | | |
| Total | | | $63,325 | | |
| | | | | | |
| Assume Five Year Simple Payback @ | | | | $12,665 | Per Yr. |
| | | | | | |
| Forecast Operating Expenses | Volume | $/Hr | $/ Yr | | |
| Natural Gas | | | | | |
| Mcf/hr @ 2.5kW | 0.032838 | $0.19 | $1,502 | | |
| Water | | | | | |
| Gals/Yr | 4918 | | $8.31 | | |
| | | | | | |
| Add Total Annual Operating Costs | | | | $1,510 | |
| Total Annual Costs (Ammortization + Expenses) | | | | $14,175 | |
| | | | | | |
| Economic Summary | | | | | |
| Forecast Annual kWH | | 19,710 | | | |
| Annual Cost of Operating Power Plant | | $0.0766 | kWH | | |
| Credit Annual Thermal Recovery | | 0 | | | |
| Project Net Operating Cost | | $0.0766 | kWH | | |
| Amount Available for Financing | | ($0.0115) | kWH | | |
| Add 5 Yr Amortization Cost / kWH | | $0.6426 | kWH | | |
| | | | | | |
| Current Demo Program Cost Assuming 5 Yr Simple Payback | | | | $0.7192 | kWH |

**NOTE**Does not include allowance for cell stack life cycle costs or service

over 5 year economic scenario.

## Project Contacts

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5 Plug Power: Scott Wilshire
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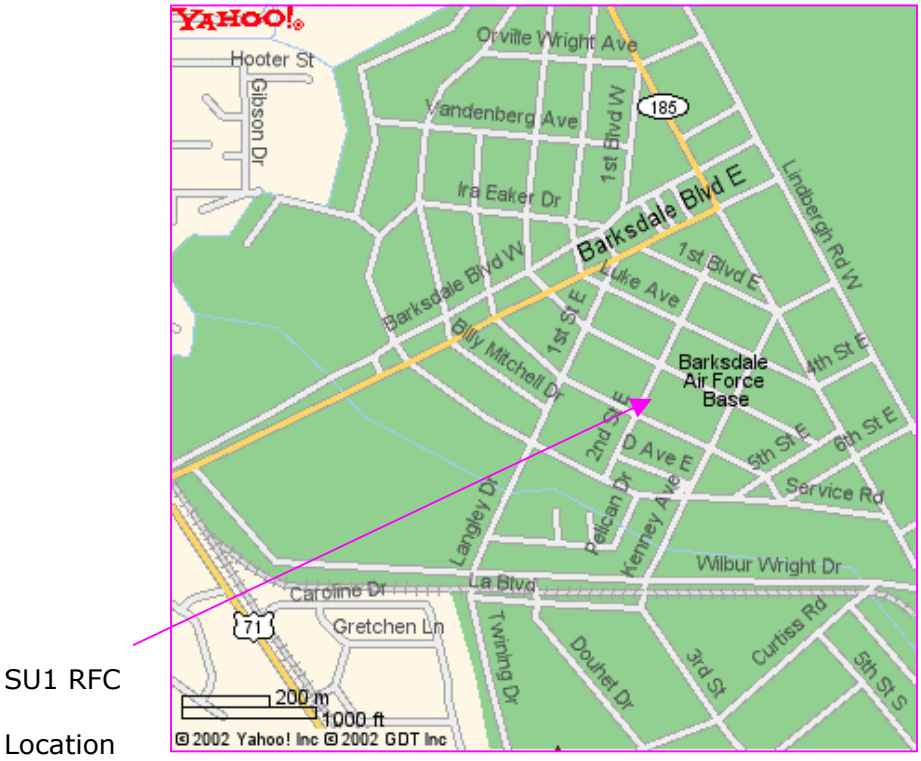


Figure 13. Barksdale AFB Site map.